# M5C6847P-1

## VIDEO DISPLAY GENERATOR

## DESCRIPTION

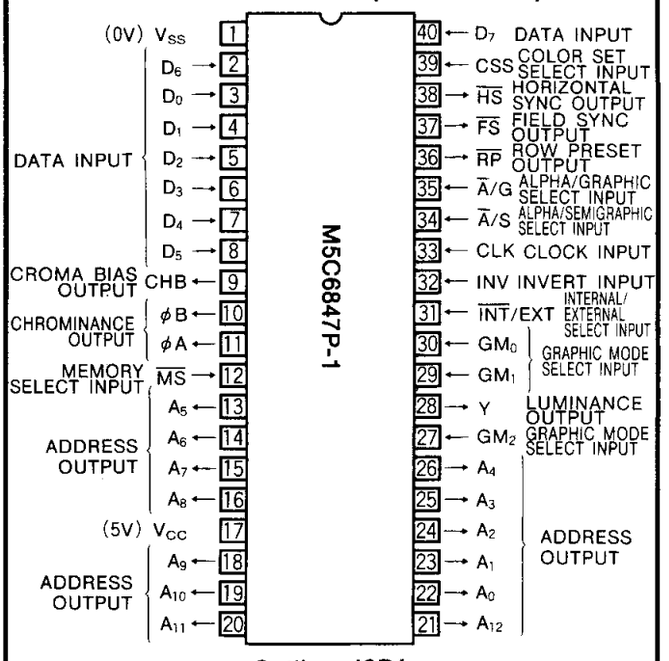
The M5C6847P-1 is a color or monochrome television interface device, fabricated using N-channel silicon gate ED-MOS technology.

The M5C6847P-1 has a 64-character (6-bit ASCII code) generator and memory interface.

## FEATURES

- Can be easily connected to the MELPS 85 series 8-bit CPUs.
- Alphanumeric display: 4 modes
- Graphic display: 8 modes
- Can connect directly with M51342P RF modulator
- Alphanumeric display: 32 characters per line by 16 lines
- Character generator for 64 ASCII characters
- Can be used with an external character generator
- Generates composite video signals
- Generates intensity signal Y, color signal R-Y ( $\phi$A) and B-Y ( $\phi$B)
- Display RAM capacity (depends on mode) : 512 ~ 6K bytes
- Single 5V power supply

## PIN CONFIGURATION (TOP VIEW)




Outline 40P4

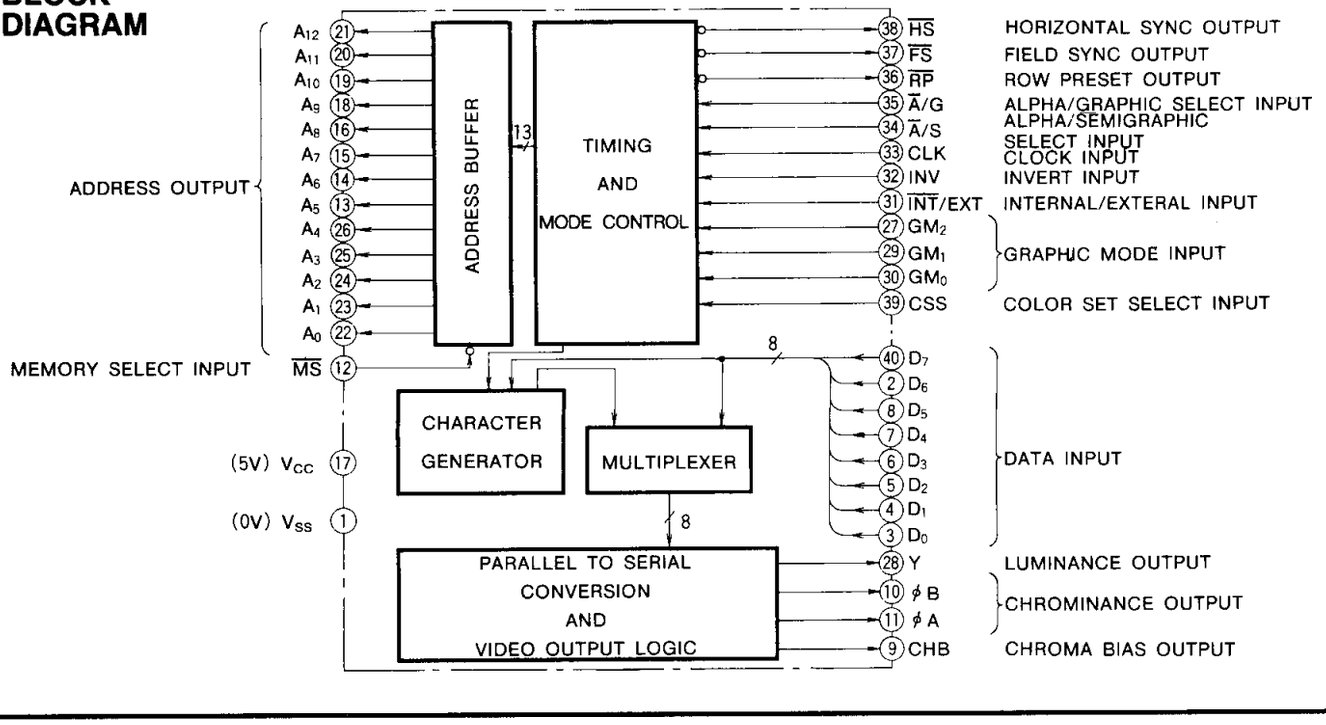
## APPLICATION

Microcomputer system or terminals using a color or monochrome CRT.

## FUNCTION

The picture on the television set is composed of the synchronization signals such as horizontal synchronization signal, vertical synchronization signal and color burst signal, and syncronizing serial data. M5C6847P-1 can generate these signals. The information or data to be shown on the screen is written in the display memory by the CPU. (When the picture is to be composed on a CRT) the data for one screen in the display memory is read in the order of the scan cycles and synchronization signals are added. This serial is sent to the RF modulator. The M5C6847P-1 performs these functions by reading the display memory in the order of the CRT scan, adding the required synchronization signals such as luminance signal, color signal and then transferring

## BLOCK DIAGRAM



the data stream serially to the RF modulator.

## OPERATION

**Data Input ($D_7$~$D_0$)**

Eight TTL-compatible data lines are used to input data from the display memory to be processed by the M5C6847P-1. The data is interpreted and transformed into video analog level signals.

**Address Outputs ($A_{12}$~$A_0$)**

Thirteen address lines are used by the M5C6847P-1 to access the display memory (refresh memory). The starting address of the display memory is located at the upper-left corner of the display screen. As the television sweeps from the left to right and top to bottom, the VDG increments the RAM display address. The address lines are TTL-compatible and may be forced in a high-impedance state when input $\overline{MS}$ goes low.

**Video Output (Y, $\phi_A$, $\phi_B$, )**

These video outputs are used to transfer luminance and color information of pictures displayed on television with standard NTSC systems. These outputs can be directly connected to the RF modulator M51342P.

**Chrominance Output ($\phi_B$)**

The chrominance output $\phi_B$ is a 4-level analog output. These levels of the signal are used in combination with $\phi_A$ and Y to specify one of eight colors. The other level is used to specify the time of the color burst reference signal.

**Chrominance Output ($\phi_A$)**

The chrominance output $\phi_A$ is a 3-level analog output. The signal is used in combination with $\phi_B$ and Y to specify one of eight colors.

**Chroma Bias Output (CHB)**

The chroma bias output is a single level analog output that provides the DC reference for chrominance outputs.

**Luminance Output (Y)**

The luminance output is a 6-level analog output. The six level analog outputs contain composite, blank, and four levels of video intensity.

**Synchronization Input ($\overline{MS}$, CLK)**

**Memory Select Input ($\overline{MS}$)**

This is a TTL compatible input. When it goes low-level, address outputs ($A_{12}$ ~ $A_0$) are forced in high-impedance state. When other devices such as the CPU access the display memory, it must be kept at low-level to prevent interference.

**Clock input (CLK)**

The clock input requires a 3.579545 MHz clock with a duty cycle of 50±5%. The M51342P RF modulator may be used to supply the 3.579545 MHz clock.

**Synchronization output ($\overline{FS}$, $\overline{HS}$, $\overline{RP}$)**

The synchronization outputs $\overline{FS}$, $\overline{HS}$ and $\overline{RP}$ are TTL-compatible and provide circuits, exterior to the M5C6847P-1 states.

**Row preset output ($\overline{RP}$)**

This signal can be used when an external character generator ROM that is used with the VDG. An external 4-bit binary counter must also be added to supply row selection.

The counter is clocked by the $\overline{HS}$ signal and cleared by the $\overline{RP}$ signal. See Table 4 ② for details.

**Table 1 Operation modes**

| $\overline{A/G}$ | $\overline{A/S}$ | $\overline{INT}$ EXT | INV | $GM_0$ | $GM_1$ | $GM_2$ | Mode |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | X | X | X | Internal alphanumerics |
| 0 | 0 | 0 | 1 | X | X | X | Internal alphanumerics inverted |
| 0 | 0 | 1 | 0 | X | X | X | External alphanumerics |
| 0 | 0 | 1 | 1 | X | X | X | External alphanumerics inverted |
| 0 | 1 | 0 | X | X | X | X | Semigraphics 4 |
| 0 | 1 | 1 | X | X | X | X | Semigraphics 6 |
| 1 | X | X | X | 0 | 0 | 0 | 64× 64 Color graphics |
| 1 | X | X | X | 1 | 0 | 0 | 128× 64 Graphics |
| 1 | X | X | X | 0 | 1 | 0 | 128× 64 Color graphics |
| 1 | X | X | X | 1 | 1 | 0 | 128× 96 Graphics |
| 1 | X | X | X | 0 | 0 | 1 | 128× 96 Color graphics |
| 1 | X | X | X | 1 | 0 | 1 | 128×192 Graphics |
| 1 | X | X | X | 0 | 1 | 1 | 128×192 Color graphics |
| 1 | X | X | X | 1 | 1 | 1 | 256×192 Graphics |

Note 1 : X is "don't care" bit.

**Table 2 Alphanumeric mode display memory, color and display element**

| Mode | Memory capacity (bits) | Color | Display elements |
|---|---|---|---|
| Internal alphanumerics | 521×8 | 2 | 8 dots, 12 dots, Character is 5 × 7 dots |
| External alphanumerics | 512×8 | 2 | 8 dots, 12 dots |
| Semigraphics 4 | 512×8 | 8 | Elements 64×32 |
| Semigraphics 6 | 512×8 | 4 | Elements 64×48 |

**Table 3 Graphic mode display memory, color and display element**

| Mode | Memory capacity (bits) | Color | Display elements |
|---|---|---|---|
| 64× 64 Color graphics | 1K×8 | 4 | 64×64 |
| 128× 64 Graphics | 1K×8 | 2 | 128×64 |
| 128× 64 Color graphics | 2K×8 | 4 | |
| 128× 96 Graphics | 2K×8 | 2 | 128×96 |
| 128× 96 Color graphics | 3K×8 | 4 | |
| 128×192 Graphics | 3K×8 | 2 | 128×192 |
| 128×192 Color graphics | 6K×8 | 4 | |
| 256×192 Graphics | 6K×8 | 2 | 256×192 |

**Field synchronization output ($\overline{FS}$)**

The high to low transition of the $\overline{FS}$ output coincides with the end of active display area. The low to high transition of $\overline{FS}$ coincides with the trailing edge of the vertical synchronization pulse. The CPU should access display memory while $\overline{FS}$ is at low-level to avoid undesired flicker on the screen.

**Horizontal synchronization output ($\overline{HS}$)**

This signal is used for horizontal synchronization on the CRT. A fall from high-level to low-level indicates the leading edge of the horizontal synchronization signal.

**Mode Control Inputs ($\overline{A}$/G, $\overline{A}$/S, $\overline{INT}$/EXT, $GM_2$, $GM_1$, $GM_0$, CSS and INV)**

These eight TTL-compatible input signals are used to determine and control the operational modes of the M5C6847P-1. Outline and details of the operational modes are shown in Table 1~3.

**Alphanumeric mode**

A screen in the alphanumeric mode is composed of 32 characters x 16 lines. Each character occupies space equivalent to an 8 x 12 dot matrix. The internal character generator can generate 64 characters (6-bit ASCII). Each character is formed by a 5 x 7 dot matrix. The low-order 6 bits of the 8-bit data input are used to select 1 of 64 characters and the remaining 2 bits can be used to implement the CSS and INV signal input. Operation in this mode requires a display memory of a least 512 bytes.

**Semigraphic 4 mode**

A screen in the semigraphics 4 mode is composed of 64 x 32 display elements. A display element is a 4 x 6 dot matrix; that is to say, each 8 x 12 character dot matrix is split into 4 display elements, each display element being a 4 x 6 dot matrix. The low-order 4 bits of the 8-bit data input correspond to the 4 display elements of a character. Three data bits of the remaining 4 bits may be used to select one of eight colors for the entire character box. The extra bit is available to switch the operation mode. Operation in this mode requires a display memory of at least 512 bytes.

**Semigraphics 6 mode**

A screen in the semigraphics 6 mode is composed of 64 x 48 display elements. A display element is a 4 x 4 dot matrix; that is to say, each 8 x 12 character dot matrix is split into 6 display elements, each display element being a 4 x 4 dot matrix. The low-order 6 bits of the 8-bit data input to the 6 display elements of a character and the remaining 2 bits are used to determine color. Operation in this mode requires a display memory of at least 512 bytes.

**Full Graphic Modes**

There are 8 full graphic modes. The border color (green or white) is selected by the level of the CSS signal. The CSS pin selects one of two sets of four colors in the four color graphic modes.

**Color Graphic Mode 64 x 64**

A screen in the 64 x 64 color graphic mode is composed of 64 x 64 display elements. Each display element can be 1 of 4 colors. Operation in this mode requires a display memory of at least 1024 bytes.

**Graphic mode 128 x 64**

A screen in the 128 x 64 graphic mode is composed of 128 x 64 display elements. Each display element can be green or white depending on the level of the CSS signal. Operation in this mode requires a display memory of at least 1024 bytes.

**Color graphic mode 128 x 64**

A screen in the 128 x 64 color graphic mode is composed of 128 x 64 display elements. Each display element can be 1 of 4 colors. Operation in this mode requires a display memory of at least 2048 bytes.

**Graphic mode 128 x 96**

A screen in the 128 x 96 graphic mode is composed of 128 x 96 picture elements. Each display element can be geeen or white depending on the level of the CSS signal. Operation in this mode requires a display memory of at least 2048 bytes.

**Color graphic mode 128 x 96**

A screen in the 128 x 96 color graphic mode is composed of 128 x 96 display elements. Each display element can be 1 of 4 colors. Operation in this mode requires a display memory of at least 3072 bytes.

**Graphic mode 128 x 192**

A screen in the 128 x 192 graphic mode is composed of 128 x 192 display element. Each display element can be green or white depending on the level of the CSS signal. Operation in this mode requires a display memory of at least 3072 bytes.

**Color graphic mode 128 x 192**

A screen in the 128 x 192 color graphic mode is composed of 128 x 192 display elements. Each picture element can be 1 of 4 colors. Operation in this mode requires a display memory of at least 6144 bytes.

**Graphic mode 256 x 192**

A screen in the 256 x 192 graphic mode is composed of 256 x 192 display elements. Each display element can be green or white depending on the level of the CSS signal. Operation in this mode requires a display memory of at least 6144 bytes.

Details of the 8 graphic modes are shown in Table 4 which gives more information in an easy to understand form.

## Table 4 Operational characteristics in the various graphic modes

| | Input Pin | | | | | | | | | Color | | | TV Screen ( 1 screen is composed of 256X192 dots) | | Data Bus | Display Mode |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\overline{MS}$ | $\overline{A}$/G | $\overline{A}$/S | $\overline{INT}$/EXT | $GM_2$ | $GM_1$ | $GM_0$ | CSS | INV | Character Color | Background | Border | Mode | Display Elements | | |
| ① | 1 | 0 | 0 | 0 | X | X | X | 0 | 0 | green | black | black | 16 lines of 32 characters | 5x7 Dots 1 Character | $D_7$ 6 5 4 3 2 1 0<br>ASCII Code | Alphanumeric mode |
| | | | | | | | | | 1 | black | green | | | | | |
| | | | | | | | | 1 | 0 | orange | black | black | | | | |
| | | | | | | | | | 1 | black | orange | | | | | |
| ② | 1 | 0 | 0 | 1 | X | X | X | 0 | 0 | green | black | black | 16 lines of 32 characters | 8x12 Dots 1 Character | External ROM Code | Alphanumeric mode |
| | | | | | | | | | 1 | black | green | | | | | |
| | | | | | | | | 1 | 0 | orange | black | black | | | | |
| | | | | | | | | | 1 | black | orange | | | | | |
| ③ | 1 | 0 | 1 | 0 | X | X | X | X | X | $D_{0\sim3}$ $D_6$ $D_5$ $D_4$<br>0 X X X black<br>1 0 0 0 green<br>1 0 0 1 yellow<br>1 0 1 0 blue<br>1 0 1 1 red<br>1 1 0 0 white<br>1 1 0 1 cyan<br>1 1 1 0 magenta<br>1 1 1 1 orange | | black | 64X32 display elements | 4 Dots<br>$D_3$ $D_2$ } 6 Dots<br>$D_1$ $D_0$<br>All 4 picture elements of the character group are the same color. The color intensity is 0 (black) or 1 (full color). | Color Luminance | Semigraphics 4 mode |
| ④ | 1 | 0 | 1 | 1 | X | X | X | 0 | X | $D_{0\sim5}$ $D_7$ $D_6$<br>0 X X black<br>1 0 0 green<br>1 0 1 yellow<br>1 1 0 blue<br>1 1 1 red | | black | 64X48 display elements | 4 Dots<br>$D_5$ $D_4$ } 4 Dots<br>$D_3$ $D_2$<br>$D_1$ $D_0$<br>All 6 picture elements of the character group are the same color. The color intensity is 0 (black) or 1 (full color). | Color Luminance | Semigraphics 6 mode |
| | | | | | | | | 1 | | 0 X X black<br>1 0 0 white<br>1 0 1 cyan<br>1 1 0 magenta<br>1 1 1 orange | | | | | | |
| ⑤ | 1 | 1 | X | X | 0 | 0 | 0 | 0 | X | $D_7$ $D_6$ ($D_5$, $D_4$, $D_3$, $D_2$, $D_1$, $D_0$)<br>0 0 green<br>0 1 yellow<br>1 0 blue<br>1 1 red | | green | 64X64 display elements | 2 Dots<br>$E_3$ $E_2$ $E_1$ $E_0$ } 3 Dots | Color $E_3$ $E_2$ $E_1$ $E_0$ | Color graphic mode 64x64 |
| | | | | | | | | 1 | | 0 0 white<br>0 1 cyan<br>1 0 magenta<br>1 1 orange | | white | | | | |
| ⑥ | 1 | 1 | X | X | 0 | 0 | 1 | 0 | X | $D_7$ ($D_6$, $D_5$, $D_4$, $D_3$, $D_2$, $D_1$, $D_0$)<br>0 black<br>1 green | | green | 128X64 display elements | 2 Dots<br>7 6 5 4 3 2 1 0 } 3 Dots | Luminance | Graphic mode 128x64 |
| | | | | | | | | 1 | | 0 black<br>1 white | | white | | | | |
| ⑦ | 1 | 1 | X | X | 0 | 1 | 0 | 0 | X | The same as ⑤ | | green | 128X64 display elements | 2 Dots<br>$E_3$ $E_2$ $E_1$ $E_0$ } 3 Dots | Color $E_3$ $E_2$ $E_1$ $E_0$ | Graphic mode 128x64 |
| | | | | | | | | 1 | | | | white | | | | |
| ⑧ | 1 | 1 | X | X | 0 | 1 | 1 | 0 | X | The same as ⑥ | | green | 128X96 display elements | 2 Dots<br>7 6 5 4 3 2 1 0 } 2 Dots | Luminance | Graphic mode 128x96 |
| | | | | | | | | 1 | | | | white | | | | |
| ⑨ | 1 | 1 | X | X | 1 | 0 | 0 | 0 | X | The same as ⑤ | | green | 128X96 display elements | 2 Dots<br>$E_3$ $E_2$ $E_1$ $E_0$ } 2 Dots | Color $E_3$ $E_2$ $E_1$ $E_0$ | Color graphic mode 128x96 |
| | | | | | | | | 1 | | | | white | | | | |
| ⑩ | 1 | 1 | X | X | 1 | 0 | 1 | 0 | X | The same as ⑥ | | green | 128X192 display elements | 2 Dots<br>7 6 5 4 3 2 1 0 } 1 Dot | Luminance | Graphic mode 128x192 |
| | | | | | | | | 1 | | | | white | | | | |
| ⑪ | 1 | 1 | X | X | 1 | 1 | 0 | 0 | X | The same as ⑤ | | green | 128X192 display elements | 2 Dots<br>$E_3$ $E_2$ $E_1$ $E_0$ } 1 Dot | Color $E_3$ $E_2$ $E_1$ $E_0$ | Color graphic mode 128x192 |
| | | | | | | | | 1 | | | | white | | | | |
| ⑫ | 1 | 1 | X | X | 1 | 1 | 1 | 0 | X | The same as ⑥ | | green | 256X192 display elements | 1 Dot<br>7 6 5 4 3 2 1 0 } 1 Dot | Luminance | Graphic mode 256x192 |
| | | | | | | | | 1 | | | | white | | | | |

## Internal Character Generator

The M5C6847P-1 generates the 64 standard ASCII characters in a 5 x 7 dot matrix form. It generates the 64 standard ASCII characters according to a 6-bit code. The code for each character is showed in Table 5.

Table 5 M5C6847P-1 character set

| Code | | | | | | Character |
|---|---|---|---|---|---|---|
| $D_5$ | $D_4$ | $D_3$ | $D_2$ | $D_1$ | $D_0$ | |
| 0 | 0 | 0 | 0 | 0 | 0 | @ |
| 0 | 0 | 0 | 0 | 0 | 1 | A |
| 0 | 0 | 0 | 0 | 1 | 0 | B |
| 0 | 0 | 0 | 0 | 1 | 1 | C |
| 0 | 0 | 0 | 1 | 0 | 0 | D |
| 0 | 0 | 0 | 1 | 0 | 1 | E |
| 0 | 0 | 0 | 1 | 1 | 0 | F |
| 0 | 0 | 0 | 1 | 1 | 1 | G |
| 0 | 0 | 1 | 0 | 0 | 0 | H |
| 0 | 0 | 1 | 0 | 0 | 1 | I |
| 0 | 0 | 1 | 0 | 1 | 0 | J |
| 0 | 0 | 1 | 0 | 1 | 1 | K |
| 0 | 0 | 1 | 1 | 0 | 0 | L |
| 0 | 0 | 1 | 1 | 0 | 1 | M |
| 0 | 0 | 1 | 1 | 1 | 0 | N |
| 0 | 0 | 1 | 1 | 1 | 1 | O |
| 0 | 1 | 0 | 0 | 0 | 0 | P |
| 0 | 1 | 0 | 0 | 0 | 1 | Q |
| 0 | 1 | 0 | 0 | 1 | 0 | R |
| 0 | 1 | 0 | 0 | 1 | 1 | S |
| 0 | 1 | 0 | 1 | 0 | 0 | T |
| 0 | 1 | 0 | 1 | 0 | 1 | U |
| 0 | 1 | 0 | 1 | 1 | 0 | V |
| 0 | 1 | 0 | 1 | 1 | 1 | W |
| 0 | 1 | 1 | 0 | 0 | 0 | X |
| 0 | 1 | 1 | 0 | 0 | 1 | Y |
| 0 | 1 | 1 | 0 | 1 | 0 | Z |
| 0 | 1 | 1 | 0 | 1 | 1 | [ |
| 0 | 1 | 1 | 1 | 0 | 0 | ¥ |
| 0 | 1 | 1 | 1 | 0 | 1 | ] |
| 0 | 1 | 1 | 1 | 1 | 0 | ↑ |
| 0 | 1 | 1 | 1 | 1 | 1 | ← |

| Code | | | | | | Character |
|---|---|---|---|---|---|---|
| $D_5$ | $D_4$ | $D_3$ | $D_2$ | $D_1$ | $D_0$ | |
| 1 | 0 | 0 | 0 | 0 | 0 | S P |
| 1 | 0 | 0 | 0 | 0 | 1 | ! |
| 1 | 0 | 0 | 0 | 1 | 0 | " |
| 1 | 0 | 0 | 0 | 1 | 1 | # |
| 1 | 0 | 0 | 1 | 0 | 0 | $ |
| 1 | 0 | 0 | 1 | 0 | 1 | % |
| 1 | 0 | 0 | 1 | 1 | 0 | & |
| 1 | 0 | 0 | 1 | 1 | 1 | ' |
| 1 | 0 | 1 | 0 | 0 | 0 | ( |
| 1 | 0 | 1 | 0 | 0 | 1 | ) |
| 1 | 0 | 1 | 0 | 1 | 0 | * |
| 1 | 0 | 1 | 0 | 1 | 1 | + |
| 1 | 0 | 1 | 1 | 0 | 0 | , |
| 1 | 0 | 1 | 1 | 0 | 1 | — |
| 1 | 0 | 1 | 1 | 1 | 0 | . |
| 1 | 0 | 1 | 1 | 1 | 1 | / |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 | 0 | 2 |
| 1 | 1 | 0 | 0 | 1 | 1 | 3 |
| 1 | 1 | 0 | 1 | 0 | 0 | 4 |
| 1 | 1 | 0 | 1 | 0 | 1 | 5 |
| 1 | 1 | 0 | 1 | 1 | 0 | 6 |
| 1 | 1 | 0 | 1 | 1 | 1 | 7 |
| 1 | 1 | 1 | 0 | 0 | 0 | 8 |
| 1 | 1 | 1 | 0 | 0 | 1 | 9 |
| 1 | 1 | 1 | 0 | 1 | 0 | : |
| 1 | 1 | 1 | 0 | 1 | 1 | ; |
| 1 | 1 | 1 | 1 | 0 | 0 | < |
| 1 | 1 | 1 | 1 | 0 | 1 | = |
| 1 | 1 | 1 | 1 | 1 | 0 | > |
| 1 | 1 | 1 | 1 | 1 | 1 | ? |

## EXAMPLE OF DISPLAY ON CRT

The M5C6847P-1 can be used to generate characters for display on a video screen. An example of a display is shown in Fig. 1.

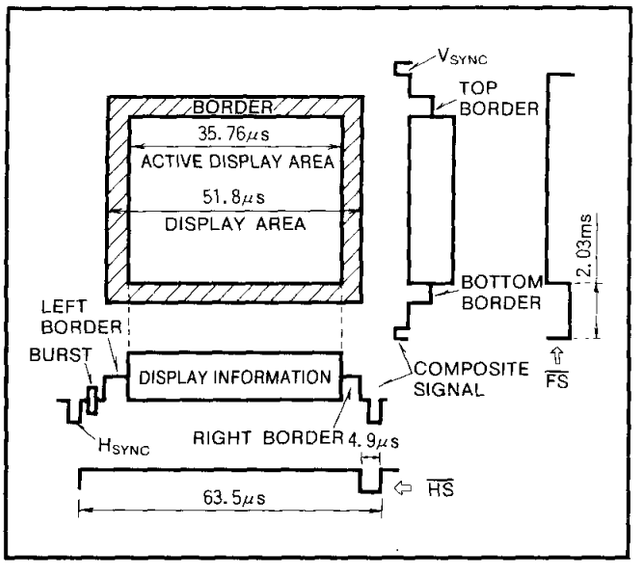



Fig. 1 Example of a display by a M5C6847P-1

## APPLICATION EXAMPLES

One example of interfacing a M5C6847P-1 with a television set for home use is shown in Fig. 2. A M5L8085AP is used as the CPU in the example shown. The CPU executes the programs to control display and write the information for one screen into display memory. The M5C6847P-1 performs the main functions of interfacing with the CRT such as synchronizing scan, reading the display information from the display memory while adding necessary synchronization signals and sending to the RF modulator.

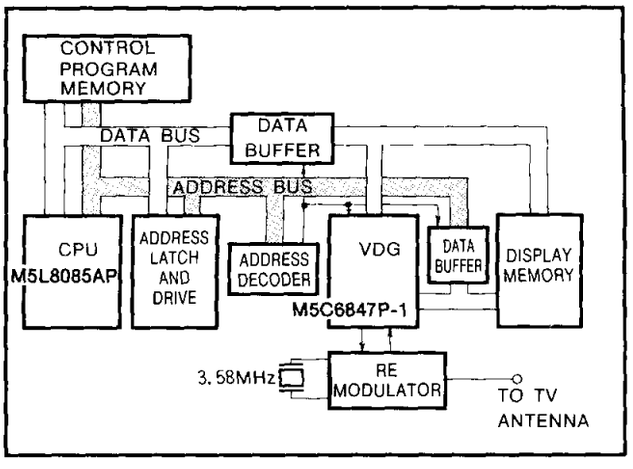



Fig. 2 Application example using the M5C6847P-1

A schematic for using the M5C6847P-1 with the M51342P RF modulator is shown in Fig. 3. M51342 requires ±5V power supplies. The video signal and chroma signal from the M5C6847P-1 can be modulated with the sound signal to form a RF signal that appears the same as the television antenna input signal. The video amplifier circuit to enable direct connection to a M5C6847P-1 is shown in Fig. 4. This can be connected to the monochrome video monitor. In this case, the impedance is 75Ω.

Four levels of brightness (black, low, medium and high) can display a clear picture.

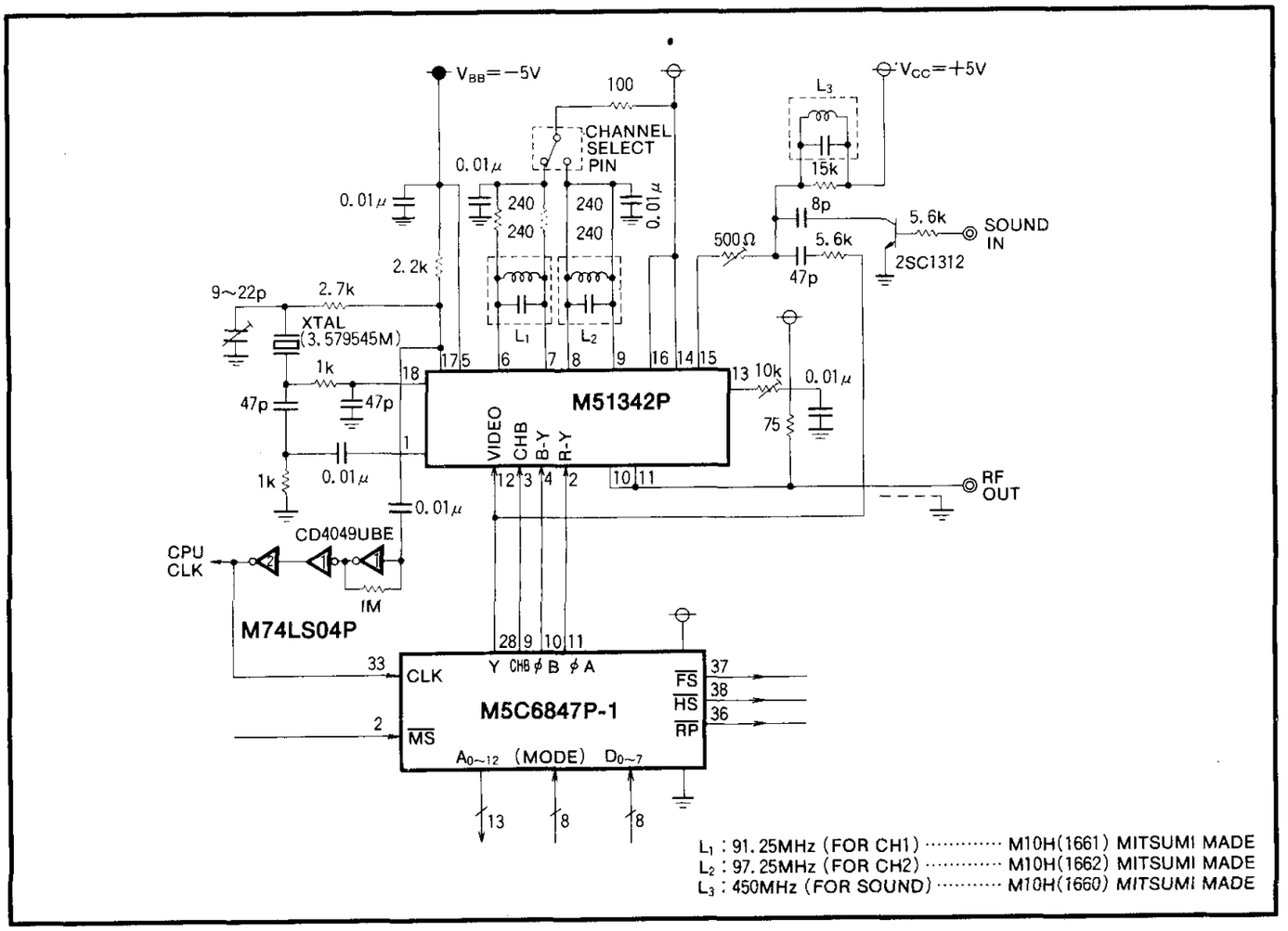



Fig. 3 Schematic for using the M51342P (RF modulator) with the M5C6847P-1

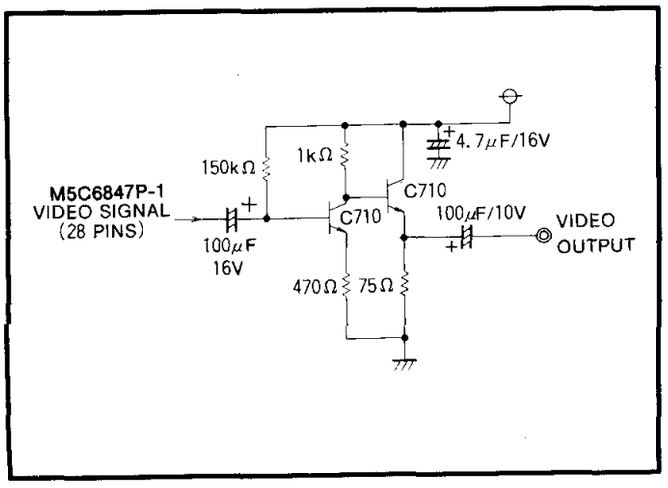
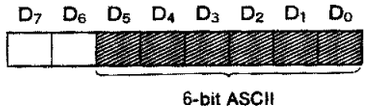
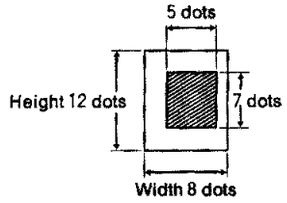
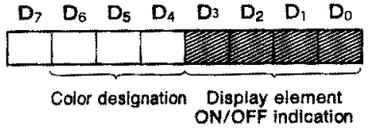
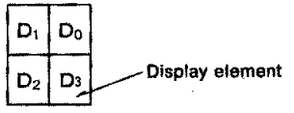
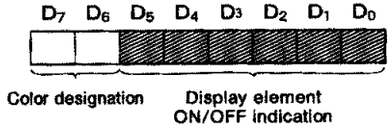
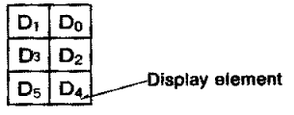
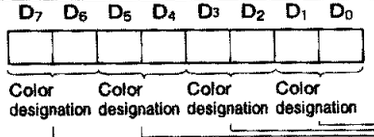
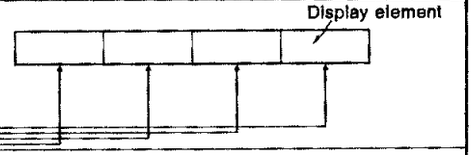
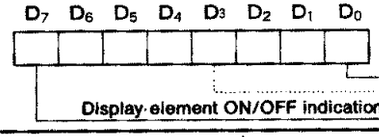
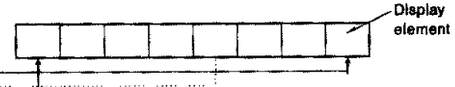



Fig. 4 Video amplifier circuit

## Data and Display Relation

The relation between data and 5 display modes is shown in Table 6.

**Table 6 Data and display relation**

| Mode | Data | Display |
|---|---|---|
| Character |  |  |
| Semigraphic 4 |  |  |
| Semigraphic 6 |  |  |
| Color-graphic (4 colors) |  |  |
| Graphic (2 colors) |  |  |

## ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Conditions | Limits | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | | −0.3~7 | V |
| $V_I$ | Input voltage | With respect to $V_{SS}$ | −0.3~7 | V |
| $V_O$ | Output voltage | | −0.3~7 | V |
| $P_d$ | Power dissipation | $T_a$=25℃ | 1000 | mW |
| $T_{opr}$ | Operating free-air temperature range | | 0~70 | ℃ |
| $T_{stg}$ | Storage temperature range | | −65~150 | ℃ |

## RECOMMENDED OPERATING CONDITIONS ($T_a$=0~70℃, unless otherwise noted)

| Symbol | Parameter | Limits | | | Unit |
|---|---|---|---|---|---|
| | | Min | Nom | Max | |
| $V_{CC}$ | Supply voltage | 4.75 | 5 | 5.25 | V |
| $V_{SS}$ | Supply voltage | | 0 | | V |
| $V_{IH(\phi)}$ | High-level input voltage, clock | 2.4 | | $V_{CC}$ | V |
| $V_{IH}$ | High-level input voltage | 2 | | $V_{CC}$ | V |
| $V_{IL(\phi)}$ | Low-level input voltage, clock | −0.3 | | 0.4 | V |
| $V_{IL}$ | Low-level input voltage | −0.3 | | 0.8 | V |

## ELECTRICAL CHARACTERISTICS ($T_a$=0~70℃, $V_{CC}$=5V±5%, unless otherwise noted)

| Symbol | Parameter | Test conditions | Limits | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $V_{OH}$ | High-level output voltage, except for $\phi$A, $\phi$B, Y, and CHB output | $V_{SS}$=0V, $I_{OH}$=−100μA, $C_L$=30pF | 2.4 | | | V |
| $V_{OL}$ | Low-level output voltage, except for $\phi$A, $\phi$B, Y and CHB output | $V_{SS}$=0V, $I_{OL}$=1.6mA, $C_L$=30pF | | | 0.4 | V |
| $I_{IH}$ | High-level input current | $V_{SS}$=0V, $V_I$=5.25V | −10 | | 10 | μA |
| $I_{IL}$ | Low-level input current | $V_{SS}$=0V, $V_I$=0V | −10 | | 10 | μA |
| $I_{OZ}$ | Output floating leak current | $V_{SS}$=0V, $V_I$=0.4V, MS=0.4V | −10 | | 10 | μA |
| $I_{CC}$ | Supply current from $V_{CC}$ | $V_{SS}$=0V | | | 150 | mA |
| $C_i$ | Input capacitance | $V_I$=0V, f=1MHz, $T_a$=25℃ | | | 10 | pF |
| $C_O$ | Output capacitance | | | | 20 | pF |
| $V_{CHB}$ | Chroma bias voltage | $V_{SS}$=0V, $C_L$=20pF, $R_L$=200kΩ | | $0.6V_{CC}$ | | V |
| $V_{\phi A,H}$ | $\phi$A chrominance high-level output voltage | | | $V_{CHB}+0.16V_{CC}$ | | V |
| $V_{\phi A,M}$ | $\phi$A chrominance medium-level output voltage | | | $V_{CHB}$ | | V |
| $V_{\phi A,L}$ | $\phi$A chrominance low-level output voltage | | | $V_{CHB}-0.16V_{CC}$ | | V |
| $V_{\phi B,H}$ | $\phi$B chrominance high-level output voltage | | | $V_{CHB}+0.16V_{CC}$ | | V |
| $V_{\phi B,M}$ | $\phi$B chrominance medium-level output voltage | | | $V_{CHB}$ | | V |
| $V_{\phi B,B}$ | $\phi$B chrominance burst-level output voltage | | | $V_{CHB}-0.08V_{CC}$ | | V |
| $V_{\phi B,L}$ | $\phi$B chrominance low-level output voltage | | | $V_{CHB}-0.16V_{CC}$ | | V |
| $V_{YSYNC}$ | Luminance sync output voltage | | | $0.74V_{CC}$ | | V |
| $V_{YBLANK}$ | Luminance blank output voltage | | | $0.85V_{YSYNC}$ | | V |
| $V_{YBLACK}$ | Luminance black output voltage | | | $0.81V_{YSYNC}$ | | V |
| $V_{YW(H)}$ | White luminance high-level output voltage | | | $0.62V_{YSYNC}$ | | V |
| $V_{YW(M)}$ | White luminance medium-level output voltage | | | $0.69V_{YSYNC}$ | | V |
| $V_{YW(L)}$ | White luminance low-level output voltage | | | $0.77V_{YSYNC}$ | | V |

## TIMING REQUIREMENTS ($T_a$=0~70℃, $V_{CC}$=5V±5%, $V_{SS}$=0V, unless other wise noted)

| Symbol | Parameter | Test conditions | Limits | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $f_{C(\phi)}$ | Clock frequency | | 3.579535 | 3.579545 | 3.579555 | MHz |
| $f_{DUTY}$ | Clock duty ratio | | 45 | 50 | 55 | % |
| $t_{r(\phi)}$ | Clock rise time | | | | 30 | ns |
| $t_{f(\phi)}$ | Clock fall time | | | | 30 | ns |
| $t_{a(A-D)I}$ | Address access time of display memory | Internal character mode | | | 900 | ns |
| $t_{a(A-D)E}$ | Address access time of display memory + Address access time of external character ROM | External character mode | | | 900 | ns |

## SWITCHING CHARACTERISTICS

### Composite video and chroma ($T_a$=0~70℃, $V_{CC}$=5V±5%, $V_{SS}$=0V, unless otherwise noted)

| Symbol | Parameter | Test conditions | Limits | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $t_{W(YSYNC)}$ | Luminance output synchronization signal pulse width | | | 4.89 | | μs |
| $t_{W(YFP)}$ | Luminance output front porch signal pulse width | | | 1.96 | | μs |
| $t_{W(YHBLANK)}$ | Luminance output horizontal blank signal pulse width | | | 11.73 | | μs |
| $t_{r(YHSYNC)}$ | Luminance output horizontal synchronization signal rise time | | | | 250 | ns |
| $t_{f(YHSYNC)}$ | Luminance output horizontal synchronization signal fall time | | | | 250 | ns |
| $t_{r(YHBLANK)}$ | Luminance output horizontal blank signal rise time | | | | 340 | ns |
| $t_{f(YHBLANK)}$ | Luminance output horizontal blank signal fall time | | | | 340 | ns |

## CHROMA

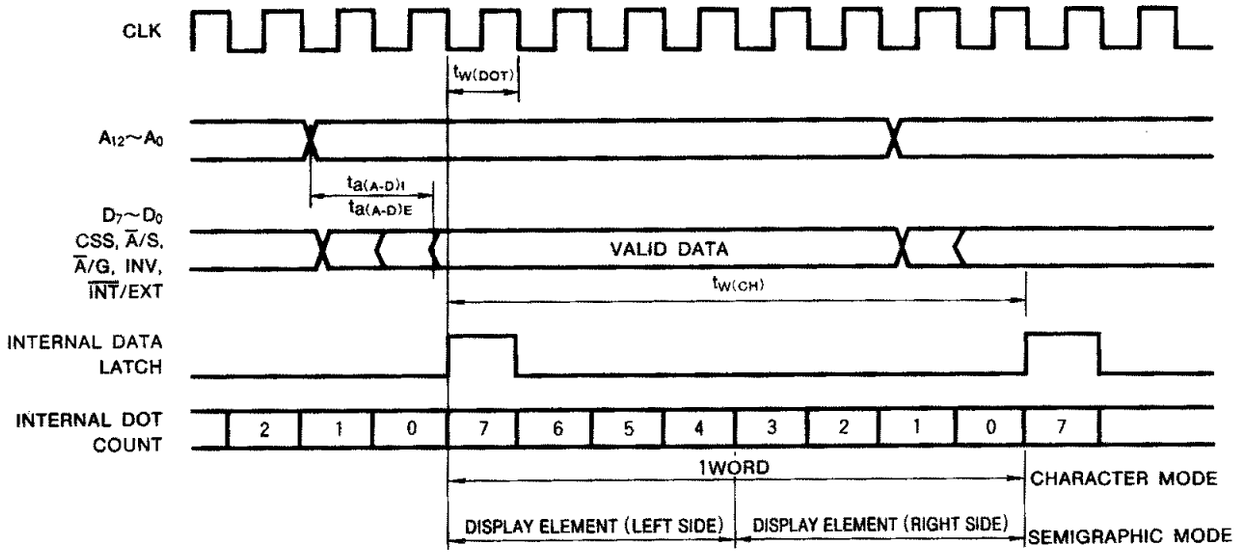
| Symbol | Parameter | Test conditions | Limits | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $t_{r(\phi A)}$ | $\phi$ A chrominance output rise time | | | 60 | | ns |
| $t_{f(\phi A)}$ | $\phi$ A chrominance output fall time | | | 60 | | ns |
| $t_{r(\phi B)}$ | $\phi$ B chrominance output rise time | | | 60 | | ns |
| $t_{f(\phi B)}$ | $\phi$ B chrominance output fall time | | | 60 | | ns |
| $t_{PHL(SYNC-BURST)}$ | $\phi$ B chrominance output propagation time after luminance syncronization signal output | | | 980 | | ns |
| $t_{W(BURST)}$ | $\phi$ B chrominance output burst signal pulse width | | | 2.93 | | μs |
| $t_{r(BURST)}$ | $\phi$ B chrominance output burst signal rise time | | | 60 | | ns |
| $t_{f(BURST)}$ | $\phi$ B chrominance output burst signal fall time | | | 60 | | ns |
| $t_{PHL(Y-CH)}$ | Chrominance propagation time after luminance output | | | 0 | | ns |
| $t_{PLH(Y-CH)}$ | | | | | | |

## MISCELLANEOUS

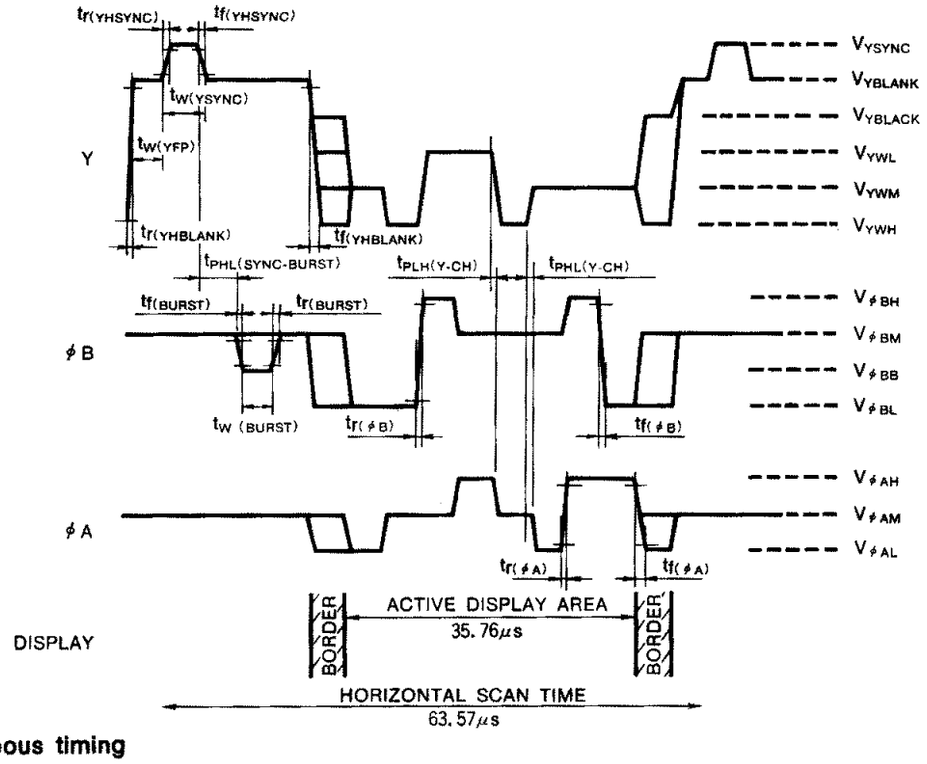
| Symbol | Parameter | Test conditions | Limits | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $t_{W(FS)}$ | Field syncronization pulse width | | | 2.03 | | ms |
| $t_{W(RP)}$ | Row preset pulse width | | | 980 | | ns |
| $t_{PHL(HS-RP)}$ | $\overline{RP}$ propagation time after $\overline{HS}$ | | | 980 | | ns |
| $t_{W(HS)}$ | Horizontal syncronization pulse width | | | 4.9 | | μs |
| $t_{W(CH)}$ | Character width | | | 1.12 | | μs |
| $t_{W(DOT)}$ | Dot width | | | 140 | | ns |

## TIMING DIAGRAM

### Display memory access




### Composite video and chroma




### Miscellaneous timing